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# Comparison of clinical outcomes between knotted and knotless double-row arthroscopic rotator cuff repairs: a meta-analysis

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**Background:** The ideal rotator cuff repair technique should allow for a quick and simple arthroscopic application which provides both adequate biomechanical stability and an appropriate biological state with the intention of promoting eventual healing of tendon to bone. While the biomechanical superiority of double-row repairs including higher repair strength, reduced gap formation, and wider footprint restoration have been proven, controversy remains regarding the clinical benefits of knotless compared with knot tying techniques. Our study aims to review the available evidence in the literature comparing the clinical outcomes between knotted and knotless transosseous double-row rotator cuff repair techniques.

**Methods:** A systematic literature search via PubMed, Embase, and Scopus was conducted by 2 independent reviewers. Studies reporting clinical outcomes of arthroscopic rotator cuff repair using the double-row knotted and knotless surgical techniques were identified. Data were analyzed with Review Manager 5.3, using Mantel-Haenszel statistics with both fixed and random effect models.

**Results:** A total of 1144 studies were identified from our initial search. Based on our inclusion and exclusion criteria, 8 studies were eventually selected for our review. The selected studies were published between 2012 and 2018. Of the 8 studies, 3 reported level 2 evidence and 5 reported level 3 evidence. There were a total of 589 subjects. Our meta-analysis revealed that there were no significant differences in functional outcomes postoperatively when comparing Constant score (mean difference = −1.85, 95% confidence interval: −4.42 to 0.73), University of California at Los Angeles score (mean differences = −0.14, 95% confidence interval: −0.90 to 0.62), and American Shoulder and Elbow Surgeons score (mean differences = −2.19, 95% confidence interval: −5.55 to 1.17) between patients who underwent knotted and knotless rotator cuff repairs.

**Discussions and Conclusion:** Our review revealed no statistically significant difference in functional outcomes between knotted and knotless transosseous double-row techniques for arthroscopic rotator cuff repairs. To our knowledge, this is the first meta-analysis related to this topic. However, no level 1 studies were available for this review. Further studies related to this topic should focus on reporting level 1 evidence comparing the clinical outcomes of knotless and knotted techniques for double-row repairs.



The ideal rotator cuff repair technique should allow for a quick and simple arthroscopic application which provides both adequate biomechanical stability and an appropriate biological state with the intention of promoting eventual healing of tendon to bone.[10]

Double-row rotator cuff repair techniques include the conventional knotted technique, the transosseous-equivalent (TOE) technique, as well as the knotless TOE technique.[7] In the TOE technique, instead of the two-row point fixation with the application of knots seen in conventional knotted technique, the rotator cuff tissue is fixed to the anatomic footprint by the help of bridging sutures. As the tendon tissue is not penetrated at the lateral row, there is decreased tissue strangulation by the knots and greater preservation of tendon vascularity.[5] In knotless TOE techniques, sutures are loaded to medial row anchors and passed through the medial row of the tendon without any knot tying to eliminate the excessive

Institutional review board approval was not required for this systematic review.

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load and tendon strangulation at the medial row and improve medial row integrity. While the biomechanical superiority of double-row repairs including higher repair strength, reduced gap formation, and wider footprint restoration have been proven, controversy regarding the clinical benefits of knotted over knotless techniques remains. Concerns with regards to knot-tying include over-tensioning of sutures and potential tissue strangulation which could affect tissue perfusion and healing.[5] The structural healing of the rotator cuff after its repair has also been shown to affect clinical outcomes, which could affect patient satisfaction after the surgery.[23] Concurrently, other studies have also discussed the biomechanical superiority of knotted repairs over knotless repairs.[1]

By following up on numerous recently published rotator cuff repair studies comparing the clinical outcomes between knotted and knotless double row repairs, there is a need for a systematic review to critically appraise the existing literature to arrive at a clinically relevant and beneficial conclusion. Our study aims to synthesize the available evidence specific to this topic to provide the most current information on outcomes of knotted vs. knotless transosseous double-row rotator cuff repair techniques.

## Methodology

### *Search strategy*

A systematic literature search was conducted, identifying all studies until 13 July 2019 involving arthroscopic rotator cuff repair using the double-row knotted and knotless surgical techniques. Relevant articles from PubMed, Embase, and Scopus were extracted by 2 independent reviewers following the Preferred Reporting Items for Systemic Reviews and Meta-Analysis guidelines. Search terms and inclusion/exclusion criteria were established a priori. The following search algorithm was used for the review: ("rotator cuff" OR "supraspinatus" OR "infraspinatus" OR "subscapularis" OR "teres minor") AND "repair" AND ("knot" OR "knotted" OR "knotless"). Eligible articles were included based on the following criteria: (1) studies reporting arthroscopic rotator cuff tear repairs using the double-row surgical technique, (2) published in a peer-reviewed journal, (3) written in English, (4) clinical studies, (5) studies reporting outcomes after the surgery, and (6) studies making direct comparisons between knotted and knotless techniques. Articles which met the following criteria were excluded: (1) articles which do not clearly report their outcomes, (2) reviews, (3) case reports, (4) studies that pooled data with other orthopedic injuries, and (5) cadaveric studies.

### *Data extraction*

Two independent reviewers independently screened all titles, abstracts, and full texts of retrieved studies to determine the eligibility of the studies. Disagreements were resolved with a discussion between the 2 reviewers, and if a consensus could not be reached, it was resolved by a third reviewer. The final decision on inclusion of studies was made after a careful review of the full-text articles. Included studies were used to extract relevant data including author, year of publication, sample size, study design, level of evidence, mean follow-up duration, surgical procedure, initial tear size, preoperative fatty infiltration, repair integrity, failure rate, location of rotator cuff failure, and any preoperative and postoperative functional scores assessed.

### *Data analysis*

All data were analyzed with Review Manager 5.3. Where articles contained raw data, unadjusted odds ratios were calculated for dichotomous data sets and mean differences (MD) were calculated for continuous data sets. All analyses were assessed for statistical significance via 95% confidence intervals (CIs) and *P*-values using Mantel-Haenszel statistics and either fixed or random effect models. For studies, for which we were unable to combine data, results from the studies along with their published odds ratios or relative risks, adjusted or crude, were described. For factors in which data had been combined, forest plots have been displayed.

## Results

A summary of the article selection process for the systematic review can be found in Figure 1. From our initial search of 3 databases, we identified 1144 studies. After removing 398 duplicates, there were 746 studies remaining. After screening titles, we read 182 abstracts. We subsequently excluded 142 further studies on the basis of inclusion and exclusion criteria as described in our methodology. We read 40 full-text articles, of which 32 were excluded owing to either the lack of direct comparisons between knotted and knotless double-row techniques or the absence of proper data analyses. A total of 8 studies were available for review. The included studies identified by the 2 independent reviewers were then evaluated by another independent reviewer to ensure that strict eligibility criteria have been met.

The included studies were published between 2012 and 2018. Of the 8 studies that were included, 3 of them reported level 2 evidence[3,11,17] and 5 of them reported level 3 evidence.[12,14,16,20,21] There were a total of 589 subjects. The male-to-female ratio was 253:206 and the mean age of all subjects was 60.5 years, although the data for both were not available in the study by Millet et al.[20] The comparisons made in the studies were between the knotted TOE and knotless TOE techniques. Mean follow-up duration of all patients was 24.8 months. Further details regarding the study characteristics of the included studies such as surgical technique, tendon torn, thickness of tear, hand dominance, and postoperative duration of symptoms can be found in Tables I and II. A list of excluded studies is available on request.

A summary of the findings of our systematic review can be found in Table III. There were no significant differences in functional outcomes postoperatively when comparing Constant score,[8] University of California at Los Angeles score,[9] and American Shoulder and Elbow Surgeons score[18] between patients who underwent knotted and knotless TOE rotator cuff repairs. We performed a meta-analysis comparing the American Shoulder and Elbow Surgeons, University of California at Los Angeles, and Constant scores of patients who underwent knotted and knotless double-row TOE rotator cuff repairs as seen in Figure 2. Taking random effects into consideration, knotted and knotless repairs did not have any statistical difference in American Shoulder and Elbow Surgeons (MD = −2.19, 95% CI: −5.55 to 1.17), University of California at Los Angeles (MD = −0.14, 95% CI: −0.90 to 0.62), and Constant (MD = −1.85, 95% CI: −4.42 to 0.73) scores. Other outcome measures such as Japanese Orthopaedic Association score,[15] Western Ontario Rotator Cuff index,[13] and Simple Shoulder Test scores[22] were reported in a single study each, with the individual studies showing no significant difference in Western Ontario Rotator Cuff and Simple Shoulder Test scores and a statistically significant difference in Japanese Orthopaedic Association score (MD = 6.40, 95% CI: 0.80 to 12.00, $P = .03$) between the two groups. Pain score reported by the visual analog scale in 1 study was found to be different between the two groups during motion but not at rest,[21] while three other studies reported no difference in pain score postoperatively.[3,11,17] Retear rates were reported in four studies (Table IV),[11,12,14,16] with just 1 study by Rhee et al[21] showing

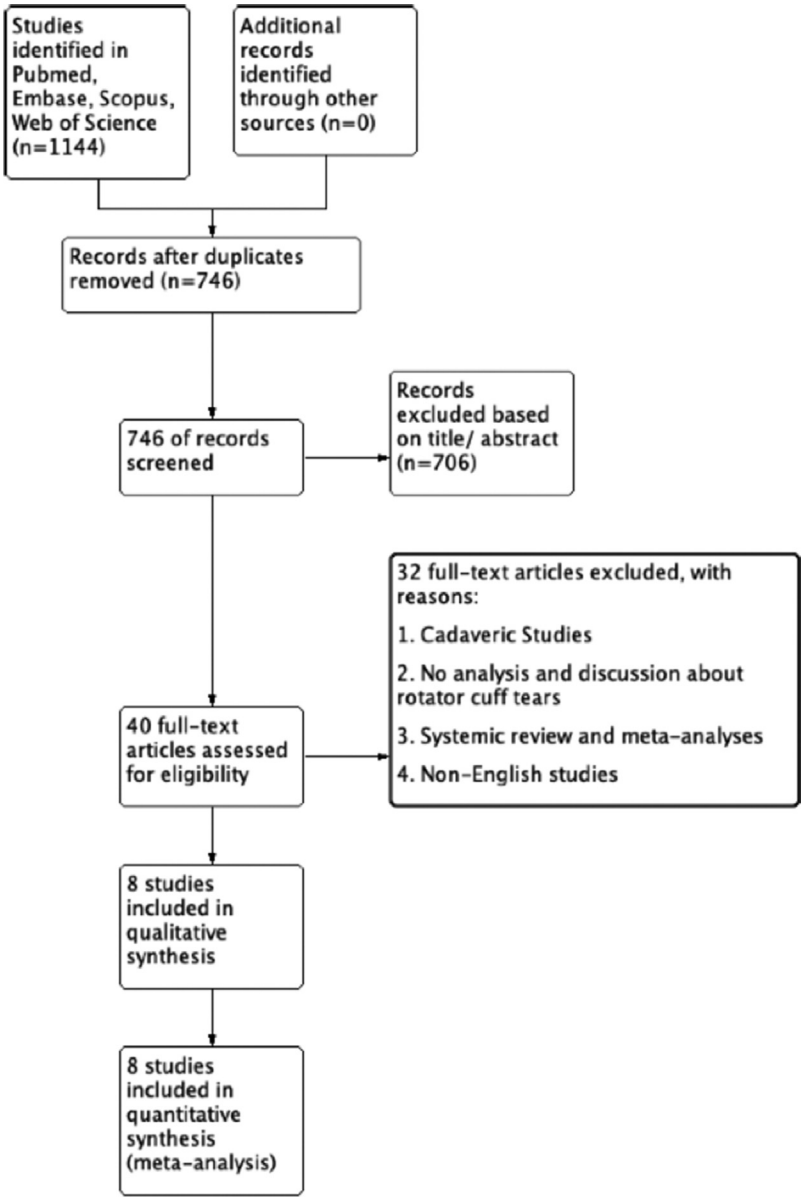


**Figure 1** PRISMA flow diagram illustrating article selection for systematic review. *PRISMA*, Preferred Reporting Items for Systemic Reviews and Meta-Analysis.

a significantly lower retear rate in the knotless group compared with the knotted group ($P < .001$).

## Discussion

Present studies are inconclusive on the superiority of either the knotted or knotless double row TOE rotator cuff repair technique over the other when it comes to postoperative functional outcomes. Our review revealed that there is no statistically significant difference in functional outcomes between knotted and knotless double-row TOE techniques for arthroscopic rotator cuff repairs. Comparison in retear rates between the 2 groups were inconclusive owing to insufficient analysis conducted in the studies included.

The ideal rotator cuff repair should allow for adequate biomechanical stability and biological factors to ensure proper healing of the rotator cuff tendons to bone. Studies have suggested that theoretically, knotted techniques, compared with knotless techniques, allow for superior biomechanical stability of repairs but are inferior biologically as they potentially can result in strangulation of tissue and thus inadequate blood flow for long-term healing. However, studies have revealed no significant difference in biomechanical stability of both repair techniques.[24]

Some of the more likely causes of medial rotator cuff failure after arthroscopic double-row repair are tension overload at the suture-tendon interface and over-tensioning of the medial repair.[25] Hence, techniques that can distribute the load placed on the medial row better are crucial to preventing this. A study by Christoforetti et al[5] revealed a reduction in tendon perfusion by nearly 50% with a TOE repair technique. The effect of tendon strangulation may be from an increased inflammatory response leading to greater shoulder stiffness.[11] The theory of knotted techniques such as the TOE technique leading to strangulation of the rotator cuff tendon at the

**Table I**
Study characteristics – study design, level of evidence, total subjects, gender ratio, mean age, duration of follow-up

| Study Technique | Study design | Level of evidence | Total subjects | M:F ratio | Age (mean) | Duration of follow-up (mo) |
|---|---|---|---|---|---|---|
| Boyer et al[3] | Prospective nonrandomized comparative cohort study | 2 | 73 | | | |
| Knotted TOE | | | 38 | 22/16 | 58* (47-72) | 29 (23-32) |
| Knotless TOE | | | 35 | 21/14 | 59* (44-68) | 21 (12-23) |
| Hug et al[14] | Prospective + Retrospective nonrandomised cohort study | 3 | 42 | | | |
| Knotted TOE | | | 20 | 15/5 | 61.2 (±7.5) | 23.4 (±2.9) |
| Knotless TOE | | | 22 | 14/8 | 63.3 (±7.2) | 24.4 (±4.8) |
| Rhee et al[21] | Retrospective cohort study | 3 | 110 | | | |
| Knotted TOE | | | 59 | 30/29 | 57.6 (range 45-70) | 22.1 (range 13-32) |
| Knotless TOE | | | 51 | 30/21 | 61 (range 44-68) | 21.2 (range 12-34) |
| Honda et al[12] | Prospective case-controlled study | 3 | 53 | | | |
| Knotted TOE | | | 29 | 17/12 | 63.8 (±9.6) | 24 |
| Knotless TOE | | | 24 | 15/9 | 65.1 (±9.6) | 24 |
| Kim et al[17] | Prospective nonrandomised comparative cohort study | 2 | 100 | | | |
| Knotted TOE | | | 50 | 28/22 | 59.4 (±7.45) | 24 |
| Knotless TOE | | | 50 | 24/26 | 59.90 (±7.66) | 24 |
| Kim et al[16] | Cohort study | 3 | 44 | | | |
| Knotted TOE | | | 22 | 11/11 | 56.8 (42-72) | 6.21 (range 3-33) |
| Knotless TOE | | | 22 | 11/11 | 63 (range 47-78) | |
| Millett et al[20] | Retrospective comparative study | 3 | 151 | 109/42 | 59 (±10) | 34.8 (range 24-64.8) |
| Knotted TOE | | | N.R. | N.R. | N.R. | |
| Knotless TOE | | | N.R. | N.R. | N.R. | |
| Heuberer et al[11] | Prospective comparative study | 2 | 37 | | | 24 (±4.7) |
| Knotted TOE | | | 20 | 10/10 | 64.8 (±7.7) | |
| Knotless TOE | | | 17 | 5/12 | 62.8 (±9.8) | |

*TOE*, transosseous-equivalent.
* Median.

medial row is also supported by Mazzocca et al,[19] revealing a failure of the medial row first with cyclic loading of double-row repair. Theoretically, the knotless TOE technique was developed to reduce tension overload at the suture-tendon interface of the medial row, hence reducing the likelihood of tendon strangulation and necrosis of the tendon at the medial row.[15,16] However, our review revealed that the knotless TOE technique still does not overcome the surgical limitations of knotted TOE techniques. Such rotator cuff repair failure not only contributes to retear rates but also to poorer functional outcomes, diminished postoperative range of motion, and increased postoperative pain scores.

Despite our study identifying a lack of difference in terms of functional outcomes and retear rates between the knotted and knotless TOE techniques, the knotless technique may provide certain advantages. In terms of the surgical approach, knot tying is technically more demanding and time-consuming, especially when executed arthroscopically,[6] and knotless techniques, on the other hand, can allow for easier suture limb management.[14] Knotless techniques also reduce operative time and costs to patients compared with knotted techniques.[2] In a biomechanical study performed, knotless repair techniques showed similar yield load, ultimate load, and cyclic displacement to knotted double-row repair.[4]

The main strength of this study is the synthesis of clinical outcome data obtained from direct comparisons made between knotted and knotless double-row rotator cuff repair techniques in individual studies. To our knowledge, this is the first review performed, which draws conclusions from such direct comparisons reported in the literature. There are a number of limitations to our review. First, our review findings are limited by both the quantity and quality of studies included. There were only 8 studies available for this review, with no level 1 studies included. Second, the studies included only compared between TOE knotted and knotless techniques, and hence, comparisons were unable to be made against conventional knotted technique. Third, a few of the studies included used slight variations in the knotless technique performed which could be a potential confounder. However, these variations still uphold the principle of the conventional knotless technique. Further studies comparing between these variations in the knotless technique would be helpful to determine any difference in clinical outcomes between them. Fouth, our analysis was not able to control for potential confounding variables such as tear size and tissue quality which could have influenced the choice of surgical technique as well as affected the postoperative outcomes. Nevertheless, the findings from this review continue to serve as a consolidation of information with regards to our current state of knowledge on outcome comparisons between knotted and knotless double-row rotator cuff repairs.

## Conclusion

There is no significant difference in functional outcomes between knotted and knotless double-row techniques when treating rotator cuff tears. Future studies should focus more on strengthening the literature with larger study size and longer follow-up periods with direct comparisons made between the two techniques.

## Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article. The authors declare no conflicts of interest in relation to this work.

**Table II**
Study characteristics – tendon torn, thickness of tear, arm involved, hand dominance, preoperative duration of symptoms, preoperative tear size, outcomes measured

| Study | Tendon torn | Thickness of tear (partial/full) | Right, left | Dominant, nondominant | Preoperative duration of symptoms (mean no. of weeks) | Preoperative tear size (no. of patients, tear size) | Outcomes measured |
|---|---|---|---|---|---|---|---|
| Boyer et al[3] | Supraspinatus | Full | N.R. | N.R. | N.R. | | Constant score, Pain, Strength, ROM |
| Knotted | | | | | | Patte's classification: 12 (type A), 20 (type B), 6 (type C) | |
| Knotless | | | | | | Patte's classification: 13 (type A), 17 (type B), 5 (type C) | |
| Hug et al[14] | Supraspinatus | N.R. | N.R. | | N.R. | N.R. | Constant score, SSV, WORC score, Sugaya |
| Knotted | | | | N.R. | | | |
| Knotless | | | | 18/4 | | | |
| Rhee et al[21] | Supraspinatus Infraspinatus Subscapularis | Full | | | N.R. | | Constant score, Pain, Strength, UCLA |
| Knotted | | | 36/23 | 38/21 | | 59 (medium) | |
| Knotless | | | 32/19 | 33/18 | | 51 (medium) | |
| Honda et al[12] | N.R. | Full | N.R. | N.R. | | | JOA, UCLA, Sugaya |
| Knotted | | | | | 35.5 (±25.2) | 2 (small), 9 (middle), 12 (large), 6 (massive) | |
| Knotless | | | | | 33.5 (±29.1) | 3 (small), 6 (middle), 9 (large), 6 (massive) | |
| Kim et al[17] | Supraspinatus Infraspinatus | Full | | N.R. | | | Constant, VAS, UCLA, ASES |
| Knotted | | | 29/21 | | 23.44 (±24) | 2.51 (1.6-4.0) anterior-posterior, 1.96 (0.8-3.5) medial-lateral | |
| Knotless | | | 34/16 | | 24.4 (±36.2) | 2.53 (1.5-3.9) anterior-posterior, 1.97 (0.5-3.5) medial-lateral | |
| Kim et al[16] | Supraspinatus Infraspinatus | Full | | N.R. | N.R. | 201 (1-4 cm) | Retear rate |
| Knotted | | | 12/10 | | | | |
| Knotless | | | 12/10 | | | | |
| Millett et al[20] | Supraspinatus | Full | N.R. | N.R. | N.R. | N.R. | ASES, SF-12 PCS |
| Knotted | | | | | | | |
| Knotless | | | | | | | |
| Heuberer et al[11] | Supraspinatus Infraspinatus Subscapularis | Full | N.R. | | N.R. | | Constant score, ROM, VAS, ASES, SST, SSV, Sugaya |
| Knotted | | | | 15/5 | | 3.1 cm (±0.4) mean | |
| Knotless | | | | 14/3 | | 2.8 cm (±0.4) mean | |

*UCLA*, University of California at Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *VAS*, visual analog scale; *WORC*, Western Ontario Rotator Cuff; *JOA*, Japanese Orthopaedic Association; *SST*, Simple Shoulder Test; *N.R.*, not reported.

**Table III**
Postoperative functional outcomes

| Outcome assessed | No. of studies | Total no. of participants | Unadjusted odds ratio (95% CI) | I2 (%) (overall effect *P* value) | Individual study risk (odds ratio or relative risk or mean difference), 95% CI |
|---|---|---|---|---|---|
| Constant score | 5 | 187 | −1.85 (−4.42 to 0.73) | 19 (0.16) | −1.30 (−5.48 to 2.88), −10.00 (−18.73 to −1.27), −1.20 (−7.88 to 5.48), −0.80 (−4.94 to 3.34), Not estimable |
| UCLA | 3 | 138 | −0.14 (−0.90 to 0.62) | 66 (0.73) | 1.20 (−0.50 to 2.90), −0.47 (−1.32 to 0.38), Not estimable |
| ASES | 3 | 70 | −2.19 (−5.55 to 1.17) | 0 (0.20) | −5.00 (−13.98 to 3.98), −1.73 (−5.35 to 1.89), Not estimable |
| VAS | 1 | 100 | 0.12 (−0.35 to 0.59) | $Z = 0.50$, $P = .62$ | 0.12 (−0.35 to 0.59) |
| WORC | 1 | 42 | 3.60 (−5.80 to 13.00) | $Z = 0.75$, $P = .45$ | 3.60 (−5.80 to 13.00) |
| SSV | 2 | 79 | 1.00 (−4.69 to 6.69) | 39 (0.73) | −3.30 (−12.01 to 5.41), 4.20 (−3.31 to 11.71) |
| JOA | 1 | 53 | 6.40 (0.80-12.00) | $Z = 2.24$, $P = .03$ | 6.40 (0.80-12.00) |
| SST | 1 | 37 | −0.40 (−2.18 to 1.38) | $Z = 0.44$, $P = .66$ | −0.40 (−2.18 to 1.38) |

*UCLA*, University of California at Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *VAS*, visual analog scale; *WORC*, Western Ontario Rotator Cuff; *JOA*, Japanese Orthopaedic Association; *SST*, Simple Shoulder Test.

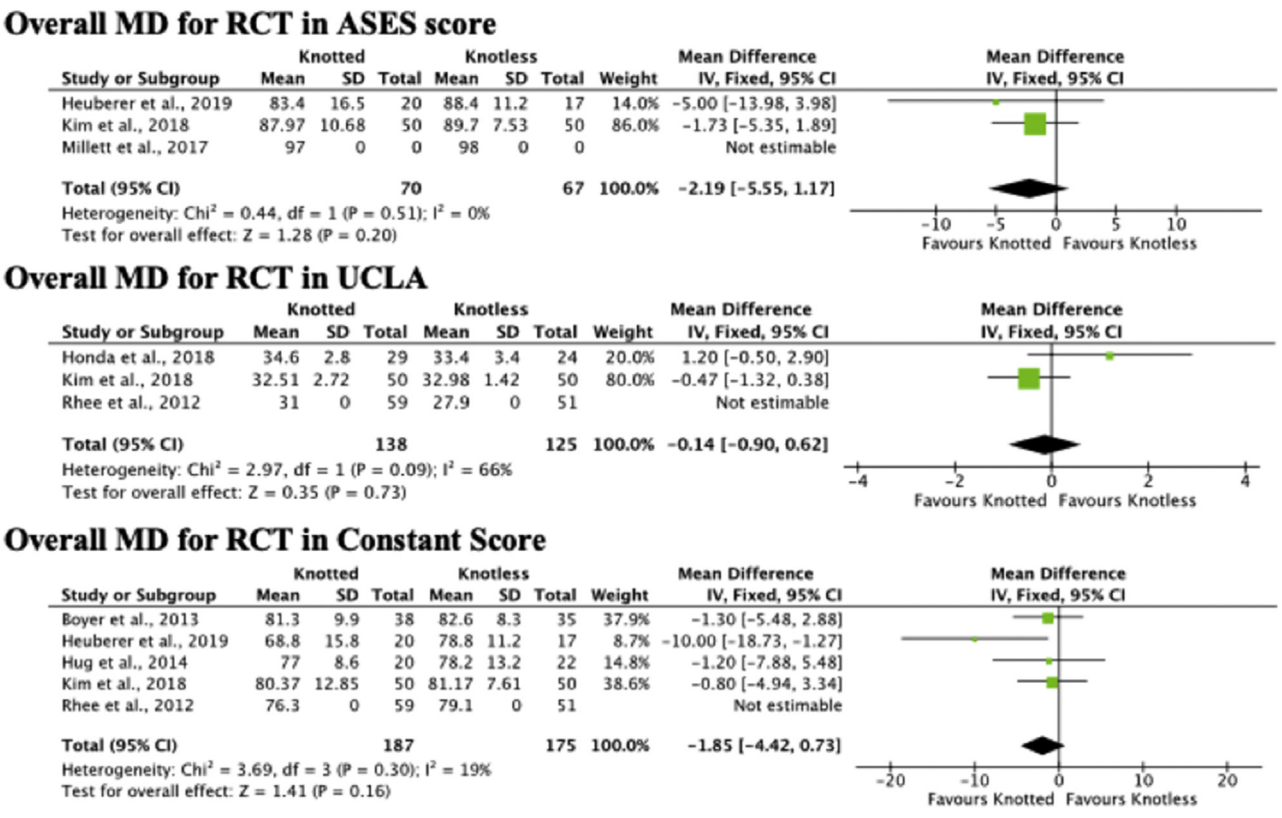


**Figure 2** Forest plots synthesizing overall mean deviation for rotator cuff tears in ASES, UCLA, and Constant scores. *ASES*, American Shoulder and Elbow Surgeons; *UCLA*, University of California at Los Angeles.

**Table IV**
Postoperative retear rates

| Study | Knotted (%) | Knotless (%) | Significance |
|---|---|---|---|
| Rhee et al[21] | 18.6 | 5.9 | <0.001 |
| Boyer et al[3] | 23.4 | 17.1 | n.s. |
| Honda et al[12] | 24.1 | 25 | n.s. |
| Kim et al[16] | 22.9 | 36.1 | Not reported |

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